Density estimates of larval lamprey in tributaries to the mainstem Columbia River

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Pacific Lamprey Biology

- Anadromous and highly fecund
- Spawning occurs on gravel beds
- Larvae drift downstream and burrow in fine sediments
- After 3-8 years, young metamorphose and migrate to the Pacific ocean where they are parasitic until maturity
- No natal homing, so adults don’t necessarily return to their natal systems and there are no district “populations”

Pacific Lamprey Status

- Lamprey are experiencing declines world-wide
- Impacts from land and water use changes and barriers
- Ecologically and culturally important
- Distribution and abundance data is needed, especially for species of conservation concern, such as Pacific lamprey
- Specifically, very little is known about larval use of larger riverine areas

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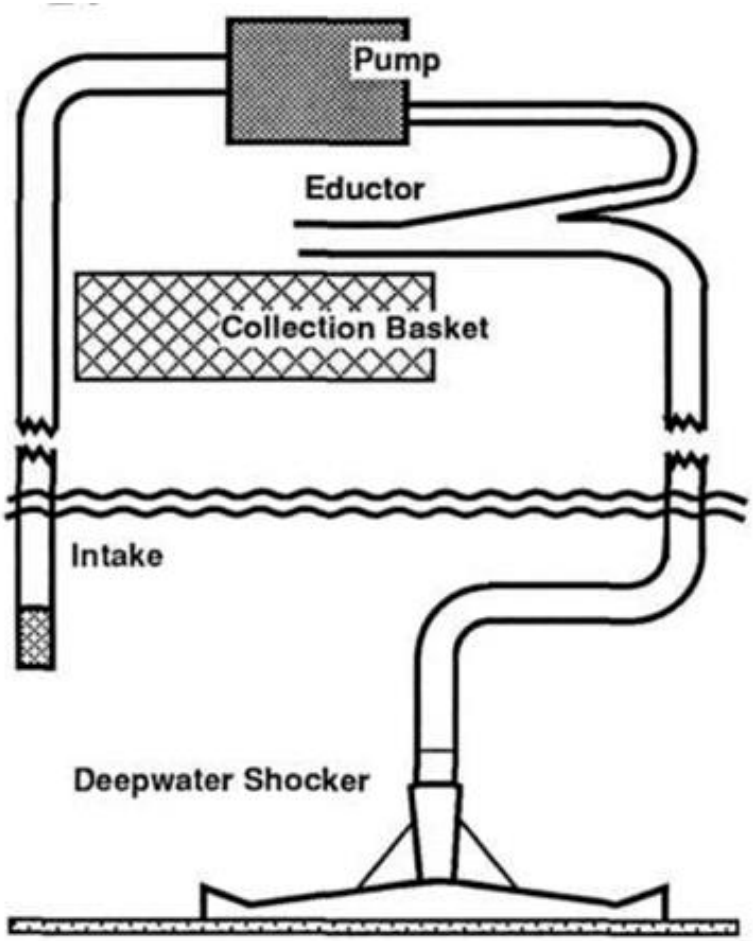
Objective:

To estimate density and local abundance of larval Pacific lamprey and *Lampetra spp.* in tributary river mouths of the Columbia River upstream of Bonneville Dam

Deepwater Electrofishing for Larvae

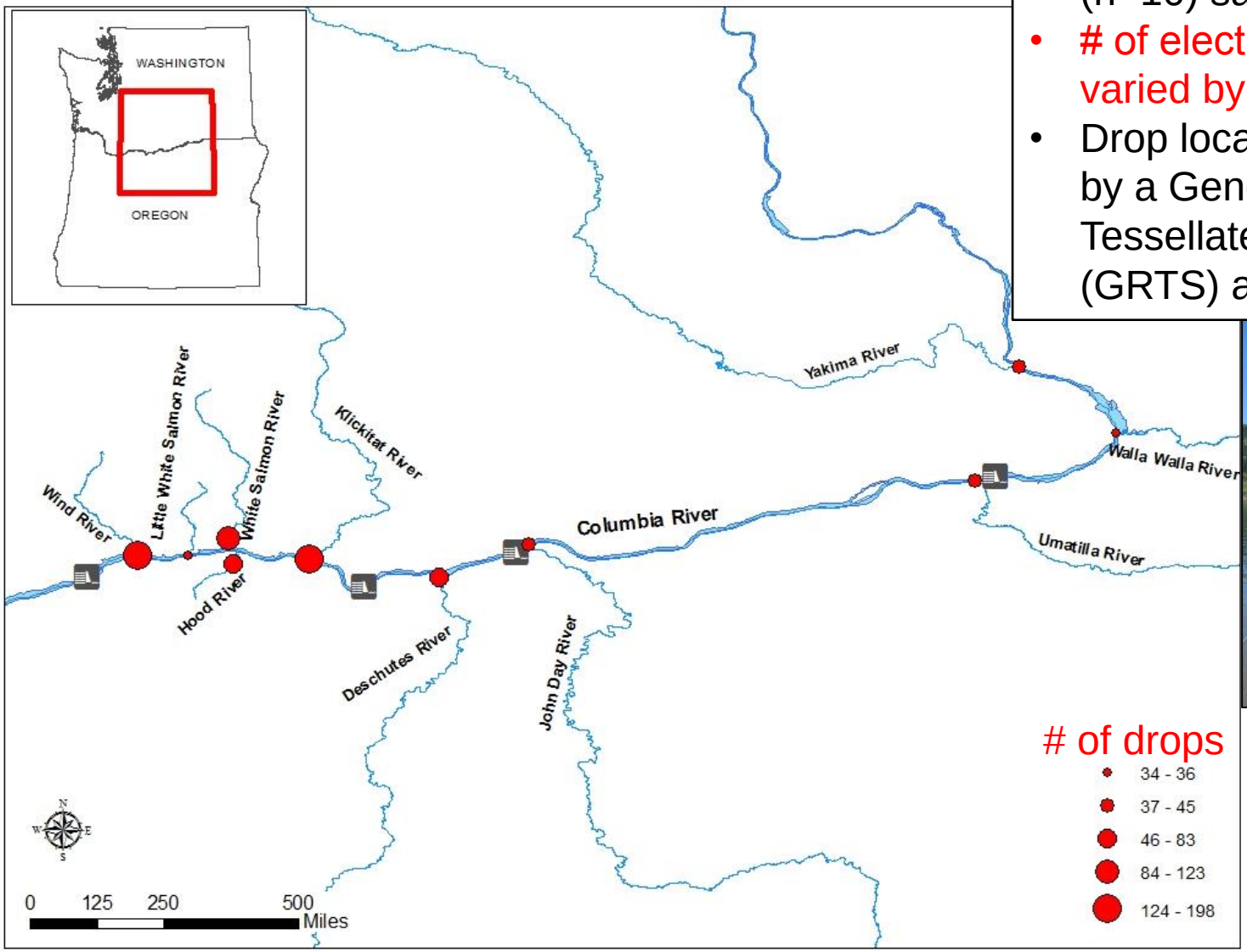
Fig.1b: Bergstedt and Genovese (1994). New technique for sampling sea lamprey in deepwater habitats.



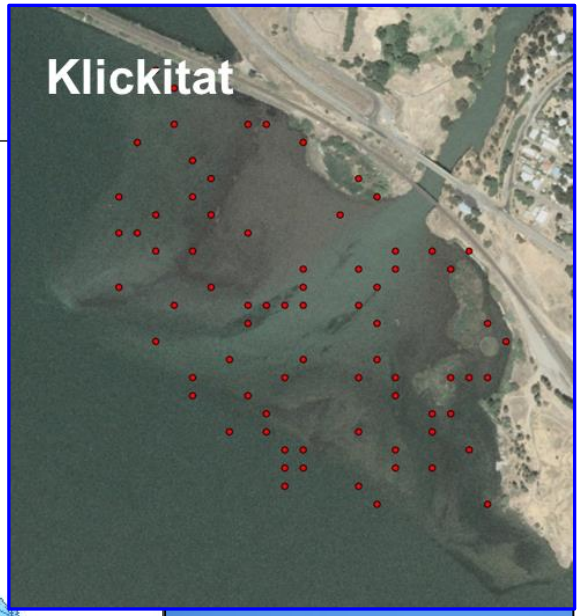
Samples 0.61 m^2 in one “drop”

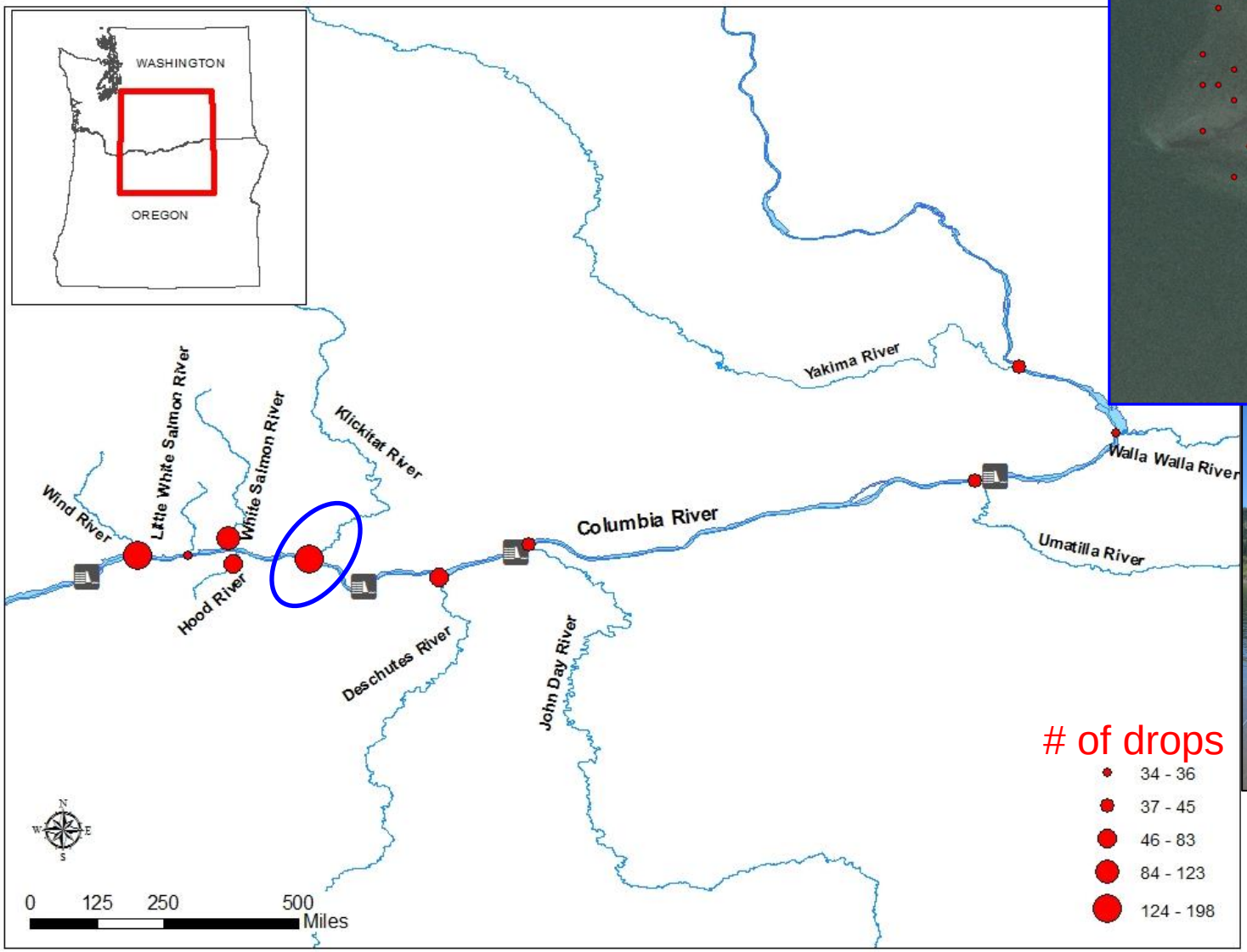
Sampling in the Columbia River System

- Tributary river mouths (n=10) sampled 2010-2015
- # of electrofishing “drops” varied by tributary
- Drop locations determined by a Generalized Random Tessellated Stratified (GRTS) approach



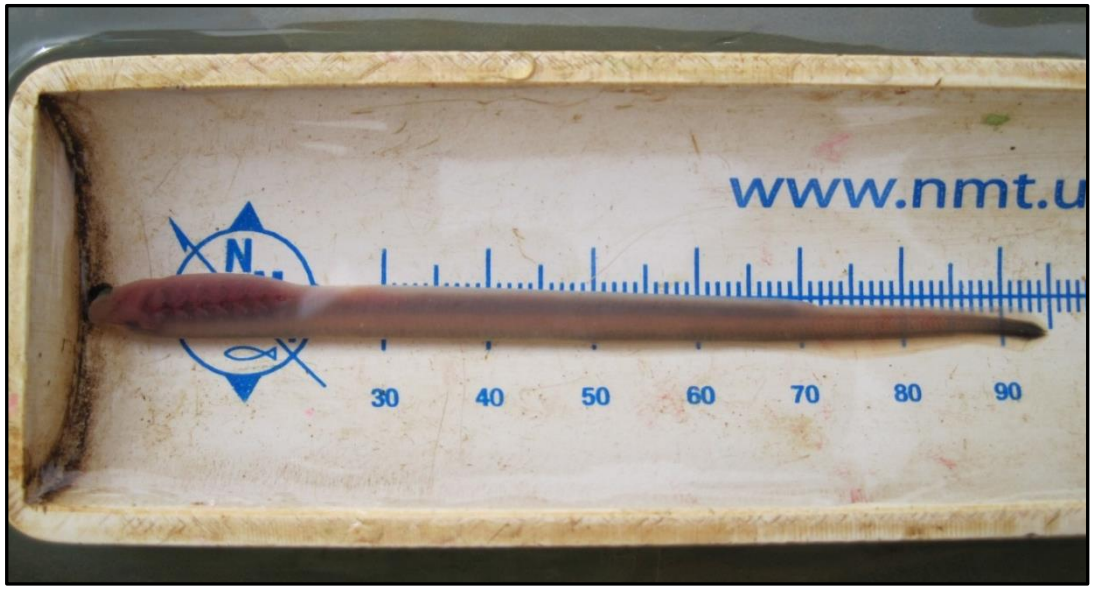
Sampling in the Columbia River System





Larval lamprey Samples

- Each captured larval lamprey was:
  - anaesthetized
  - measured for total length (mm)
  - fin clipped for genetic identification
    - *Lampetra spp.*
    - Pacific lamprey



Density and abundance estimates

- We used a zero-inflated N-mixture model to estimate larval lamprey abundance in one electrofishing drop
- **Three hierarchical levels:**

1. $Z_i \sim \textbf{Bernoulli}(\Omega)$
   1. Z_i is the probability that a specific tributary (i) could be occupied
   2. Ω is the proportion of tributaries that could be occupied
2. $\text{Abundance}_{i,j} \sim \textbf{Poisson}(e.\lambda_{i,j})$ (i.e., by tributary (i) and drop (j))
   1. $e.\lambda_{i,j} = Z_i * \text{Expected Abundance}_{i,j}$
   2. $\text{Log}(\text{Expected Abundance}_{i,j}) = \text{Intercept} + e_{i,j}$ (evaluated for overdispersion)
3. $\text{Count}_{i,j} \sim \textbf{Binomal}(\text{Abundance}_{i,j}, p)$

- Detection probability (p) is usually estimated by repeated sampling, but we estimated it from an experimental study since repeated sampling was not possible.

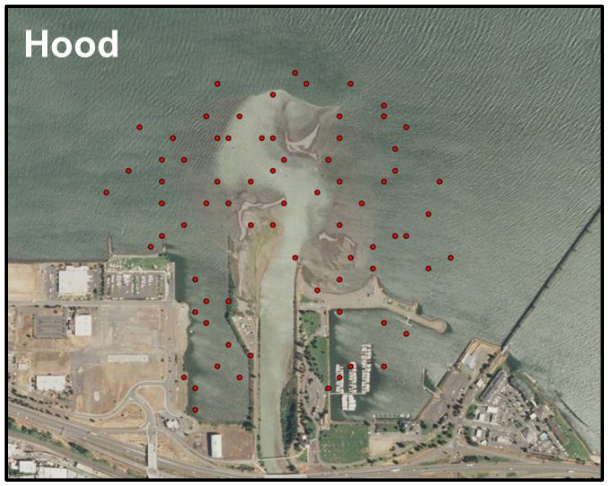
Experimental study to estimate p

- Troughs were subdivided into 0.61 m^2 chambers (n=23)
- 5-7 cm of fine sediment and water were added
- 24 hours later, 5-10 larval lamprey were added
- Each chamber was sampled by deepwater electrofishing
- Detection probability was estimated using the binomial model:

$$\text{Catch}_{\text{Chamber}} \sim \textbf{Binomial}(\#\text{Seeded}_{\text{Chamber}}, p)$$

Analysis

- Tributary mouth density (in m^2): average tributary mouth abundance divided by the area of a drop (0.61 m^2)
- Tributary mouth abundance: estimated density multiplied by the estimated area of the tributary mouth

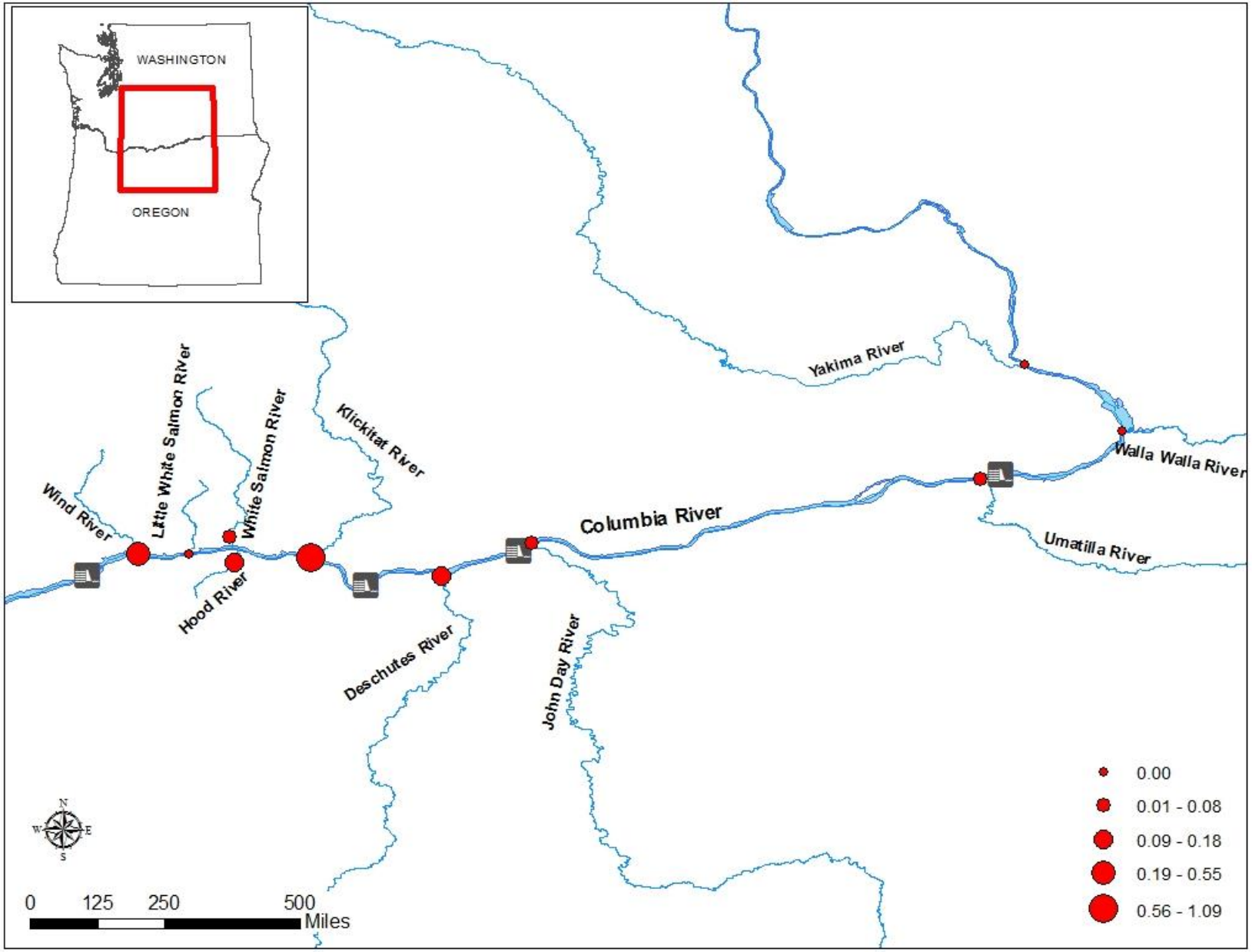


- Evaluated by Bayesian methods using OpenBUGs software
  - All priors were selected to be uninformative
  - Two initial chains, a large enough burnin to achieve convergence (20,000) and enough iterations to produce stable parameters (30,000)

General Results

- 112 of 170 larvae seeded into 23 chambers were collected
- Detection probability (p) of a deepwater electrofishing drop was thus estimated to be 0.66 (95%:0.58-0.73)
- 813 drops were made in tributary river mouths (~496 m^2)
  - 143 larval Pacific Lamprey
  - 115 larval *Lampetra spp.*
  - 18 unknown larvae that escaped (not included in analysis)
- For Pacific Lamprey:
  - Ω = 0.72 (0.41 – 0.94)
  - Standard deviation for overdispersion = 2.98 (2.28 – 3.78)
- For *Lampetra spp*.:
  - Ω = 0.51 (0.24 – 0.79)
  - Standard deviation for overdispersion = 2.38 (1.91 – 3.08)

Pacific Lamprey Density

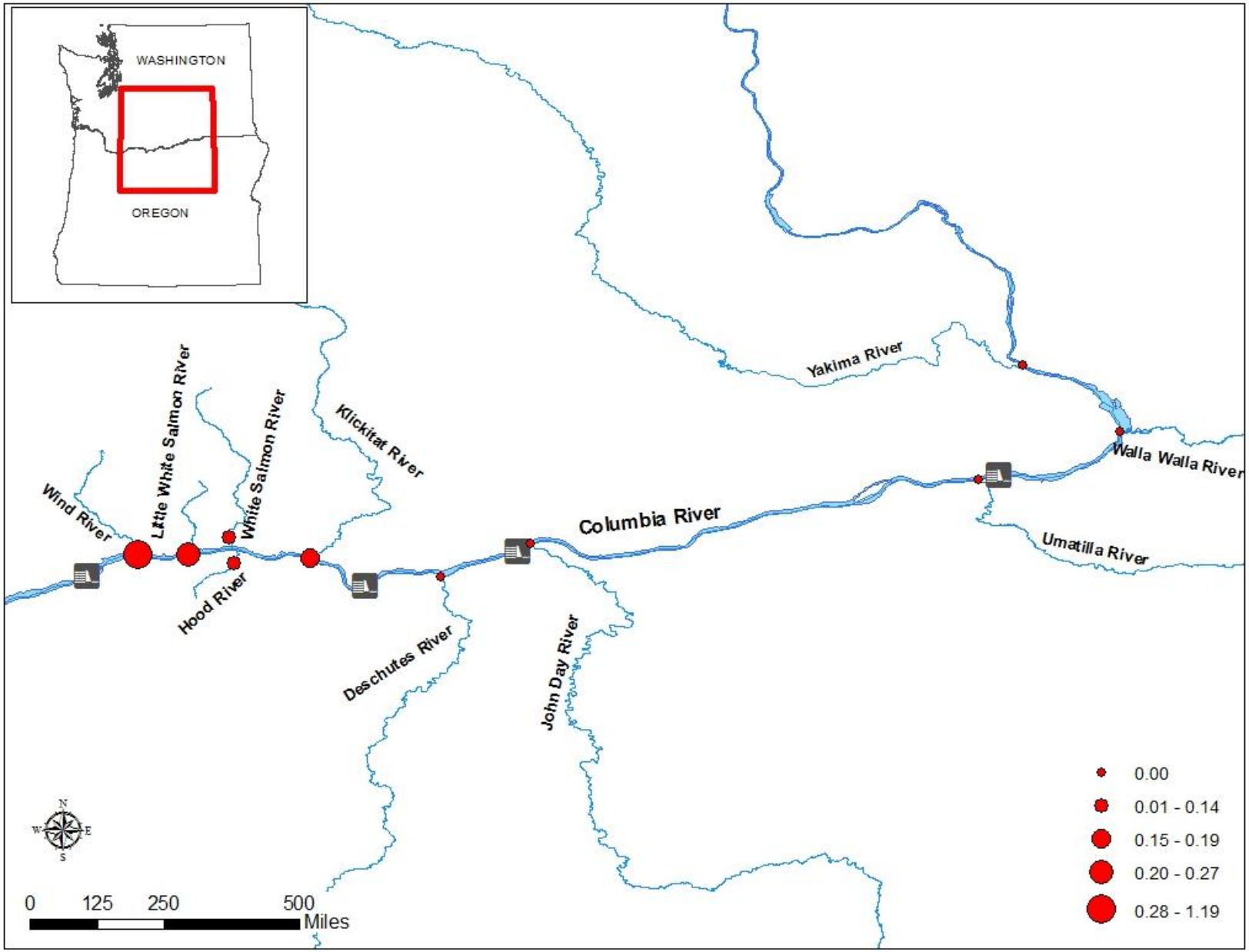


Pacific Lamprey Abundance

Bonneville
The Dalles
John Day
NcNary

Tributary name	Mean probability of potential occupancy	Abundance
Wind River	1	175,600 (145,800 – 217,300)
Little White Salmon River	0.18	0 (0 – 31,560)
White Salmon River	1	30,440 (15,220 – 60,890)
Hood River	1	63,960 (36,550 – 109,600)
Klickitat River	1	350,400 (305,000 – 414,600)
Deschutes River	1	68,390 (42,750 – 119,700)
John Day River	1	4,390 (2,195 – 13,170)
Umatilla River	1	33,440 (16,720 – 83,610)
Walla Walla River	0.20	0 (0 – 56,760)
Yakima River	0.10	0 (0 – 31,540)

Lampetra spp. Density



Lampetra spp. Abundance

Bonneville
The Dalles
John Day
NcNary

Tributary name	Mean probability of potential occupancy	Abundance
Wind River	1	380,900 (330,300 – 446,400)
Little White Salmon River	1	94,670 (63,110 – 173,600)
White Salmon River	1	50,740 (30,440 – 86,260)
Hood River	1	63,960 (36,50 – 118,800)
Klickitat River	1	61,530 (42,800 – 85,600)
Deschutes River	<0.01	0 (0 – 0)
John Day River	0.03	0 (0 – 0)
Umatilla River	0.04	0 (0 – 16,720)
Walla Walla River	0.06	0 (0 – 28,380)
Yakima River	0.02	0 (0 – 0)

Conclusions

- Deepwater electrofishing capture probability was 0.66—more studies are needed in wild systems
- Pacific lamprey were found in most tributary mouths upstream of Bonneville, but densities may decline by reservoir
- Although found in McNary Reservoir, *Lampetra spp*., may not be present in tributaries upstream of Bonneville Reservoir
- N-mixture model estimates were moderately precise
- With reasonable sampling effort, estimating local abundance is possible for larval lamprey
  - Estimates may not be adequate in areas with low density
  - Only relatively large changes in abundance would be detectable